Deep Site Goals for the COUPP 4 kg Chamber

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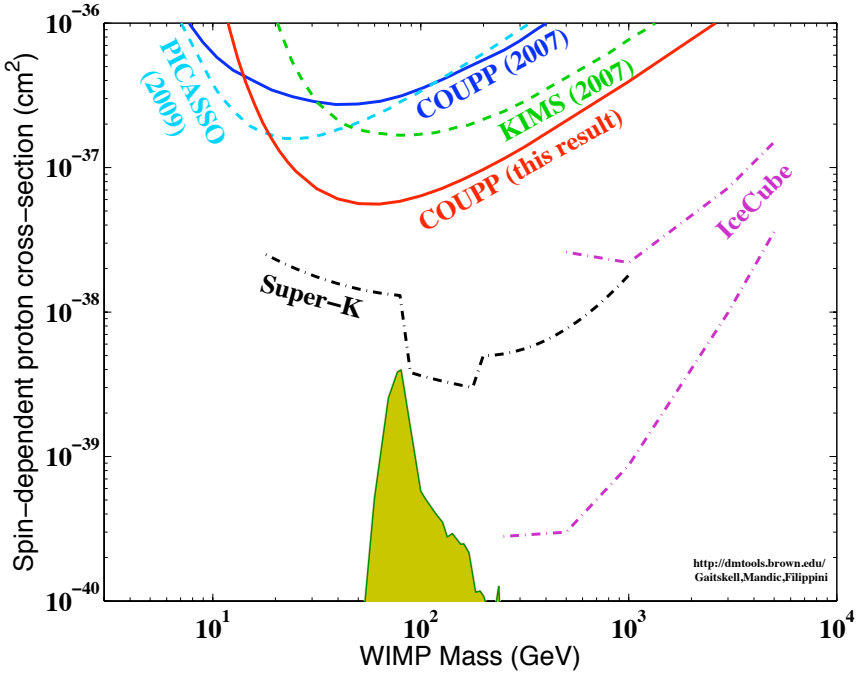
Deep Site Goals

- Dark matter search
- Alpha discrimination measurement
- Operations development

4 kg NuMI Run

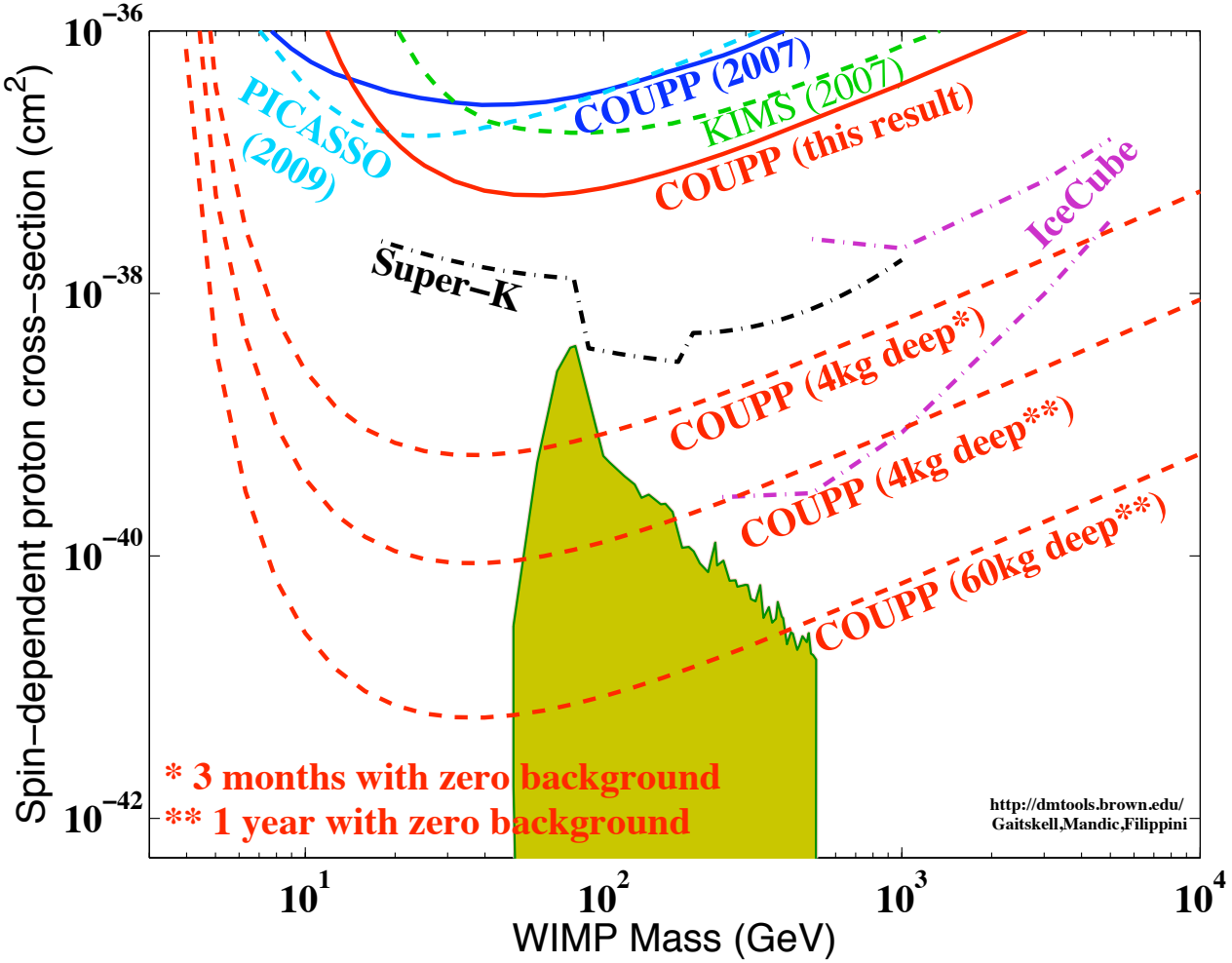
- Data quality was excellent
- Limited by neutrons
  - 3 neutron scatters in 18 kg days
  - Similar to other well shielded shallow searches
- Best direct detection spin-dependent WIMP-proton cross-section limit



4 kg SNOLAB Goal

- 3 months with no background
  - New acoustic sensors will be installed
  - Only passive shielding will be used
- Lower threshold than NuMI run
  - NuMI was 20 keV (30° C, 27 PSIA)
  - SNOLAB goal is 10 keV (40° C, 27 PSIA)
- Similar alpha rate of ~1 alpha decay / kg CF_3I / day
  - No special fluid handling required
  - Will not use black tubing and will use gold o-ring (teflon o-ring known to eminate radon)

SNOLAB expected sensitivity



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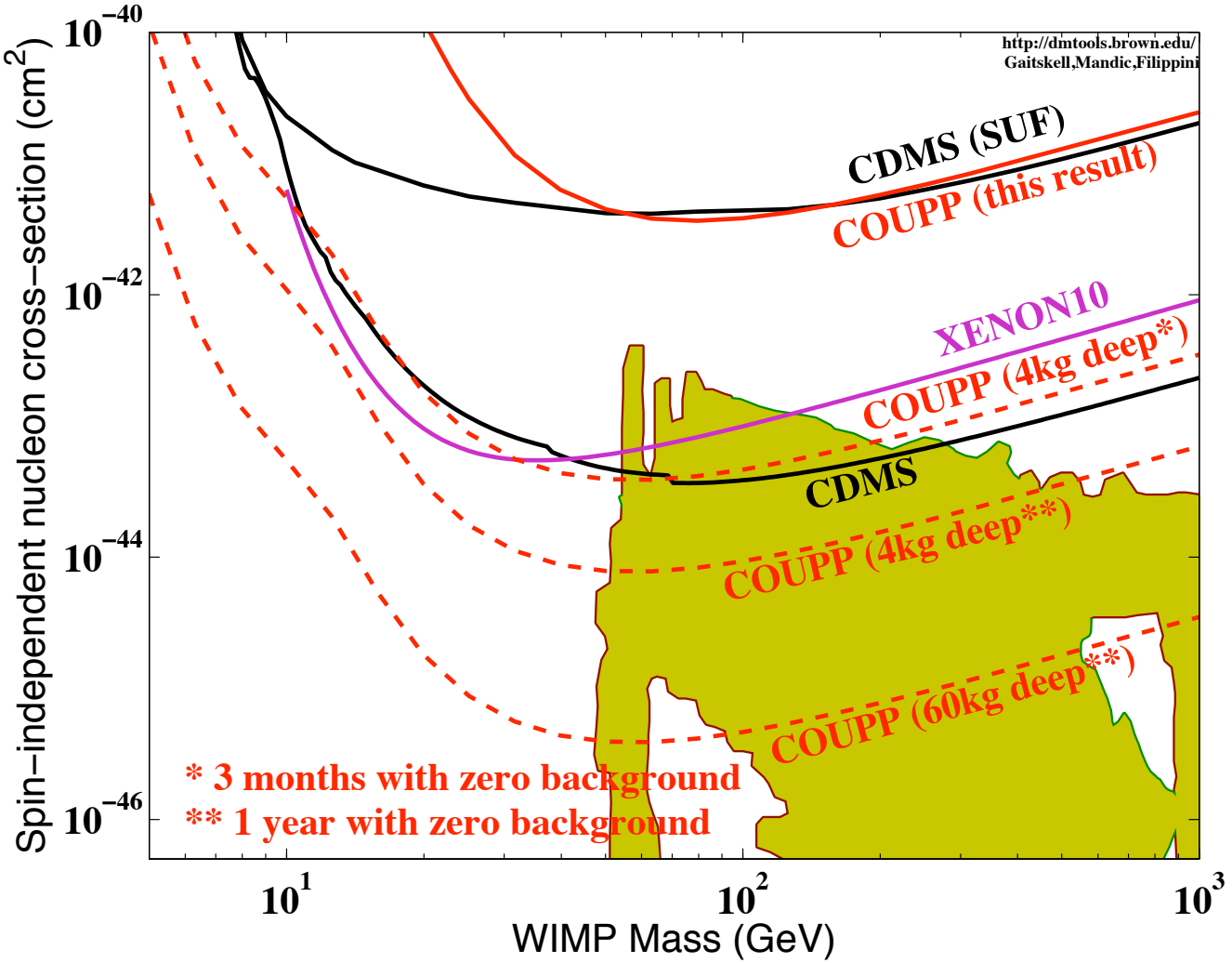

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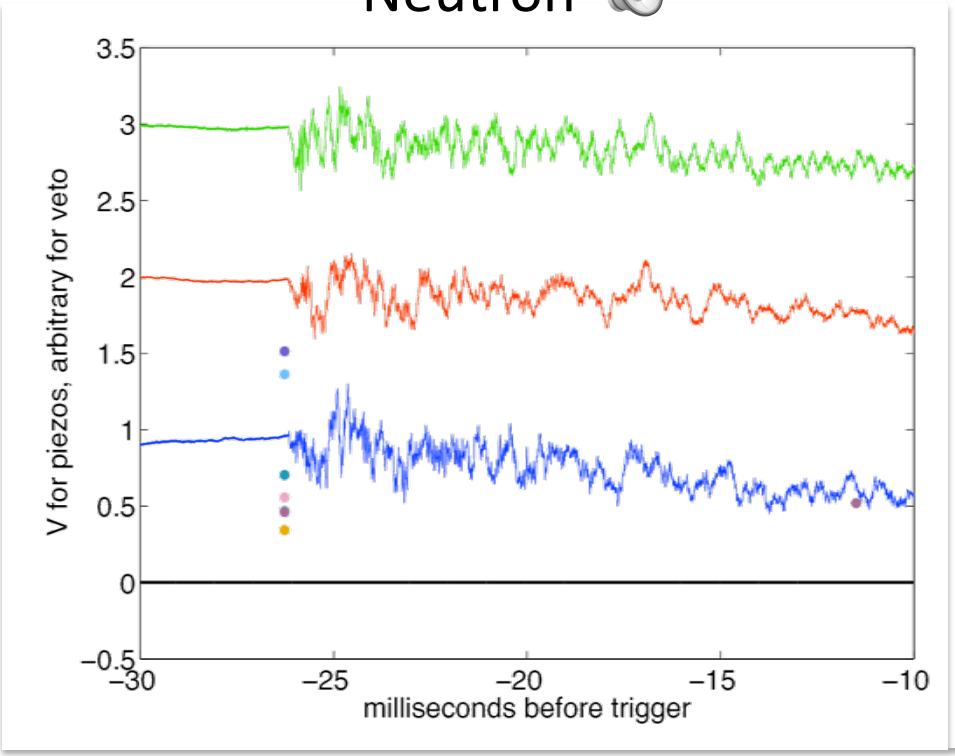
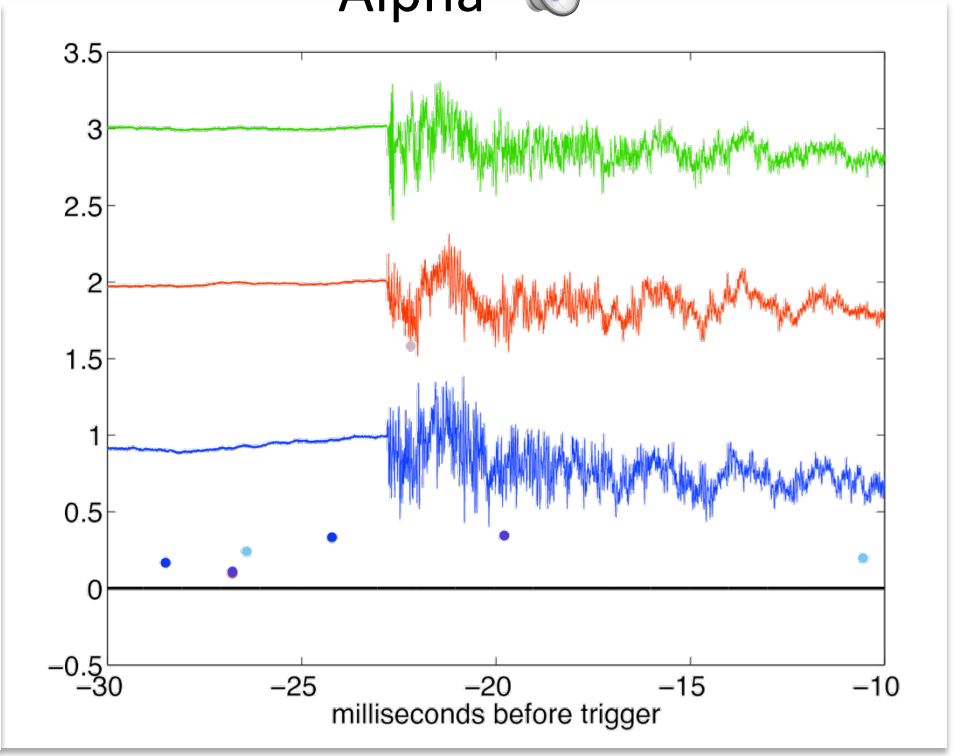
4 kg NuMI Run

Neutron



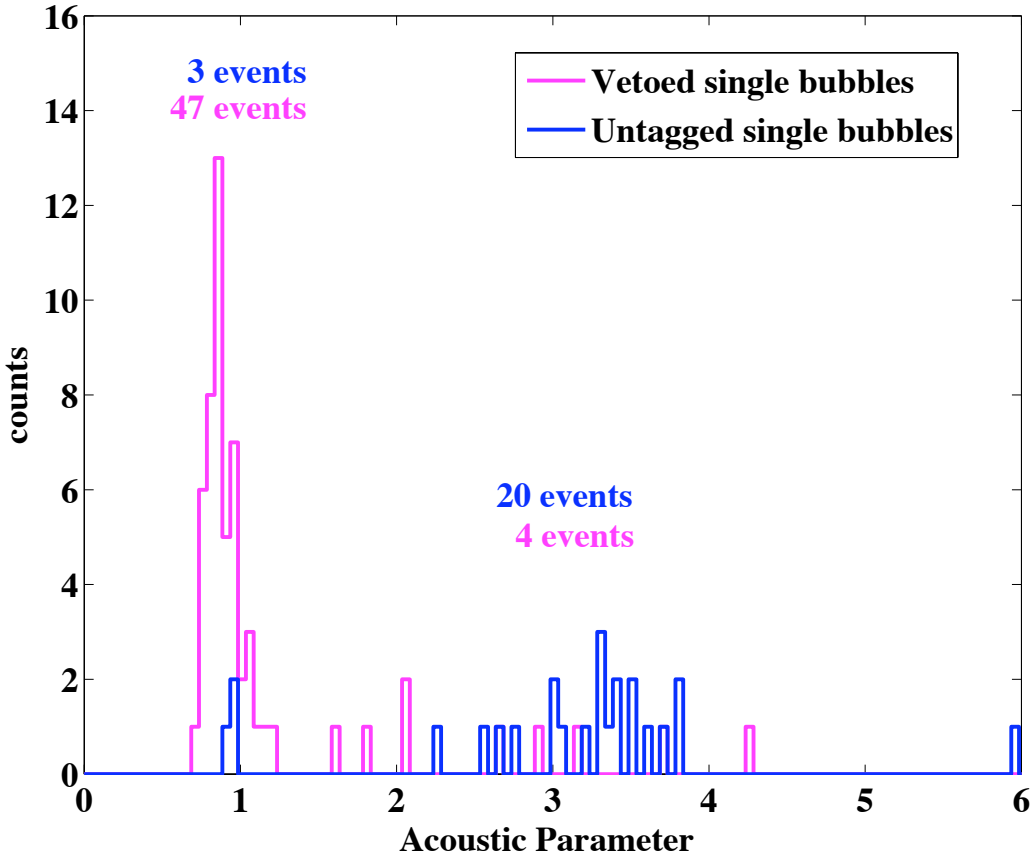
Alpha



- Alpha events observed to have significantly more power at high frequency
- "Acoustic Parameter" constructed to quantify this difference

4 kg NuMI Run

- Low alpha rate
  - 0.7 alphas/kg/day (1.8 per day)
- Discrimination measurement limited
  - >80% *discrimination*
  - ~88% *efficiency*
  - well *separated peaks*
  - *Low signal to background ratio in region of interest*



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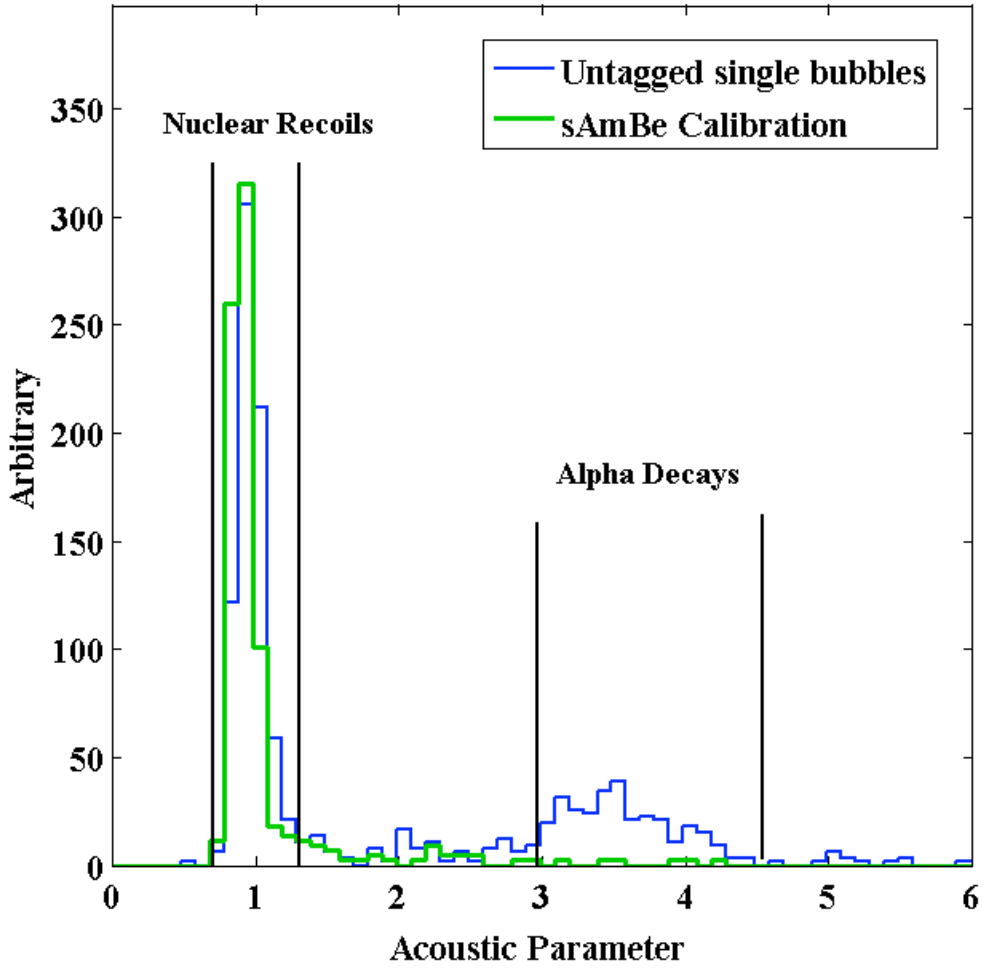

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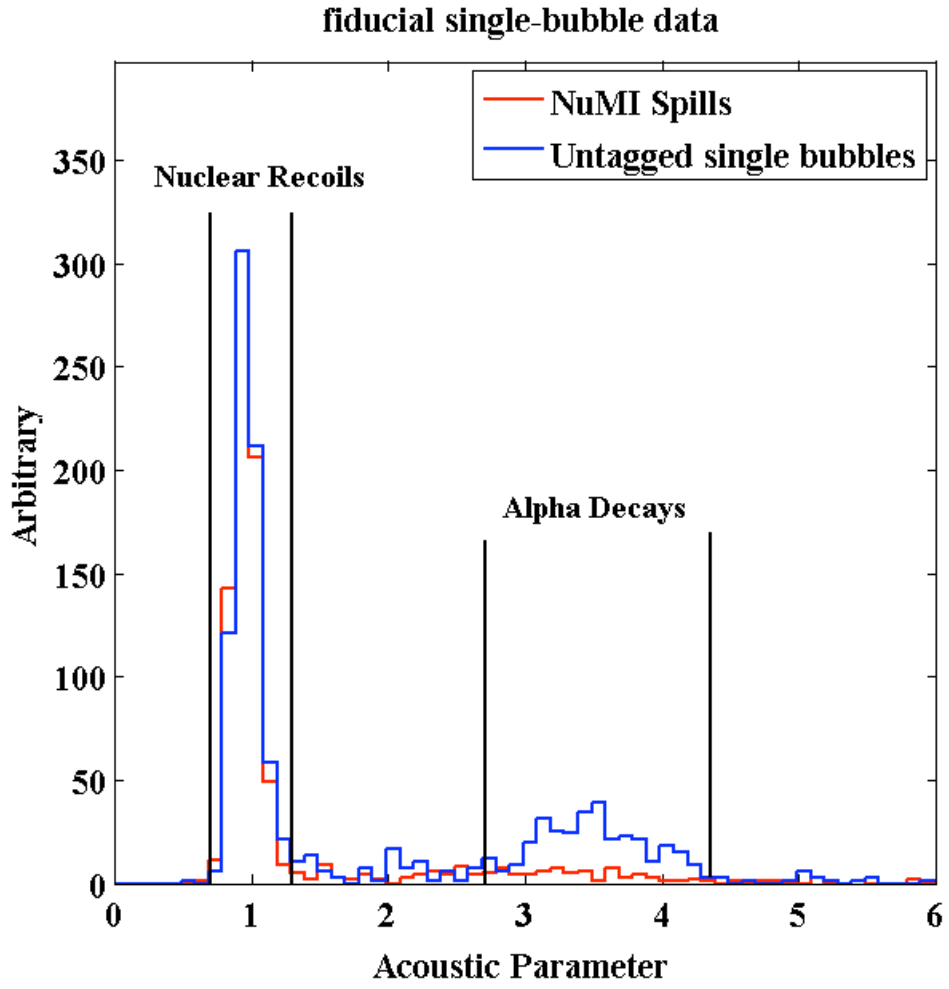
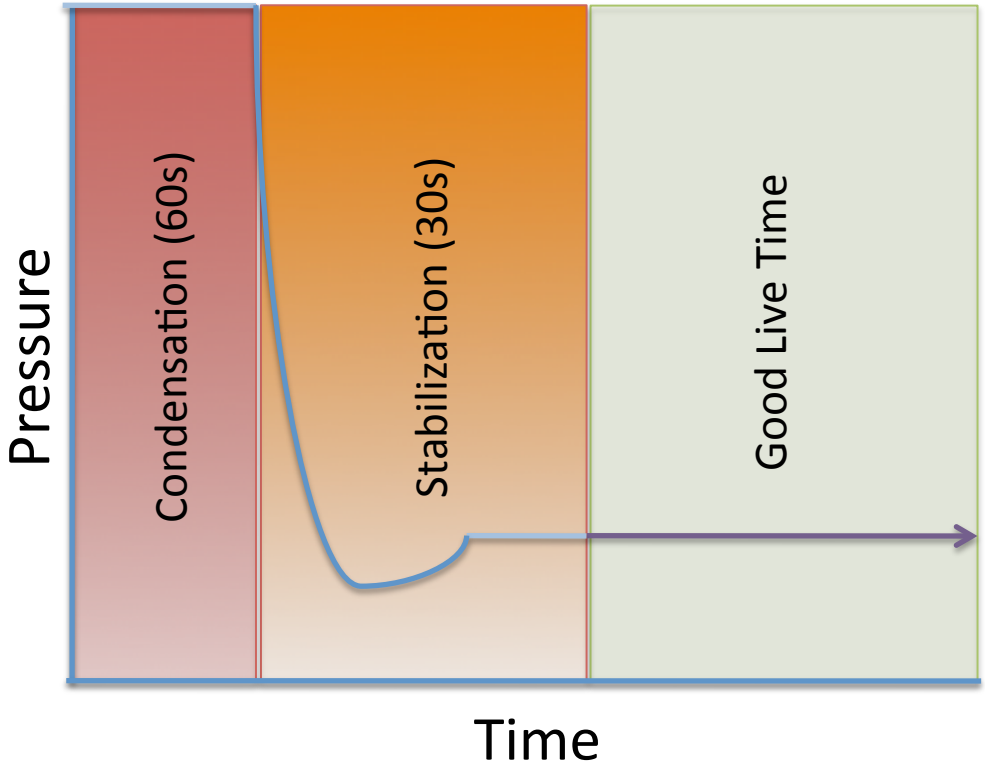


4 kg SNOLAB Alpha Discrimination Goals

- Measure alpha discrimination to 1:100 during low background physics run
  - 0.7 alpha/kg/day X 300 kg day = 210 alpha events
- Develop a method of injecting alpha decays into the active volume
  - At an understood rate of ~100 per day
  - Without contaminating the fluid with long lived isotopes
  - Necessary for dark matter discovery in all future chambers

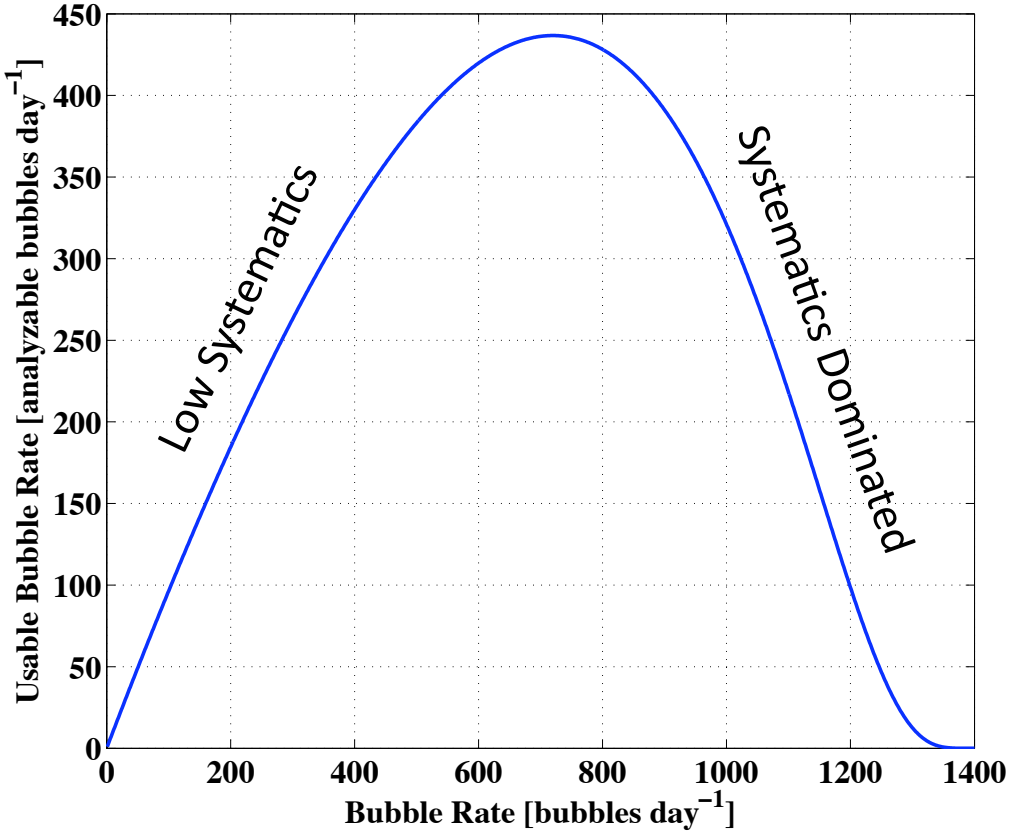
Dark Matter Bubble Chamber Cycle

- Each good expansion cycle includes 90 sec of deadtime
- For ~30 sec of the deadtime, alpha decays will cause bubbles
- There is a large dependence of the acoustic signal on pressure
- Therefore there are significant hard limits on alpha calibrations



Dark Matter Bubble Chamber Calibration Limitations

- Each good expansion cycle includes 90 sec of deadtime
- For ~30 sec of the deadtime, alpha decays will cause bubbles
- There is a large dependence of the acoustic signal on pressure
- Therefore, 1:10000 is the ultimate sensitivity of *any* calibration (and that takes months of optimized calibrations with no background)



Deep Site Goals

- Dark matter search
- Alpha discrimination measurement
- Operations development

Operations Goals

- Develop personnel comfortable working in SNOLAB
- Understand paperwork and documentation requirements by operating in SNOLAB
- Develop shielding required by the sensitivity goals of future dark matter experiments
  - Types of shielding (water, polyethylene, scintillator)
  - Safety and cleanliness requirements of shielding
- Develop relationships with our Canadian colleagues

Summary

- A run of the 4 kg in a deep site will significantly advance the state of the art of bubble chambers for WIMP searches
  - Continue testing acoustic discrimination in a device that has demonstrated excellent performance
  - Develop alpha source techniques for bubble chambers
- The science goals are significant enough to warrant operation of the 4 kg in a deep site
  - World class sensitivity to both spin-dependent and spin-independent WIMP-nucleon couplings
- There are significant synergies between the operation of the 4 kg and 60 kg chambers
  - In-situ alpha sources are required for a dark matter discovery in all future bubble chambers
  - A world class science result will cement bubble chambers as a (the) leading technology for the direct detection of dark matter
  - Building relationships with SNOLAB and Canadian colleagues will strengthen the COUPP collaboration
  - Developing operations expertise and experience in SNOLAB will accelerate that transition for the 60 kg